Technical Analysis
for Prevention of Significant Deterioration
Prudhoe Bay Oil Field

I. Introduction

SOHIO Petroleum Company (SOHIO) and Atlantic Richfield Co. (ARCO) have applied for a PSD permit on behalf of the unit owners of the Prudhoe Bay Oil Field for expansions which include facilities for Produced Water Injection, Artificial Lift, Low Pressure Separation and Waterflood. The Waterflood facilities are covered under a separate PSD application. Approval was granted by the EPA in 1979 for a facilities expansion which included the installation of 11 natural gas fired turbines. The unit owners have since determined that further expansion is necessary to increase rates of oil recovery and field offtake.

The proposed expansion would involve the installation of 42 gas fired combustion turbines totaling 827,000 hp (617 Mw) and 31 gas fired heaters totaling 1,530 million BTU/hr. (The locations of these facilities are illustrated in Table 1 and Figure 1.) NO_x and CO will be the primary pollutants emitted, with particulate emissions also over the PSD applicability criterion requiring PSD review. Therefore, a BACT determination and an air quality analysis are required for all sources emitting these pollutants. Tables 2 and 3 give summaries of the potential emissions from all sources.

The proposed methods to limit pollutant emissions involve primarily the use of natural gas as the fuel for the units along with dry combustion controls on the turbines to limit NO_x.

II. Determination of Best Available Control Technology (BACT)

Definition of BACT

When filing for a PSD permit the source must demonstrate that it intends to install the best available control technology (BACT) to limit emissions for each pollutant. The emission limit established for the source will be the maximum reduction achievable by the use of process modification and emission control systems as determined by the permitting authority. Determination is made on a case by case basis taking into account energy, economic, and environmental impacts. BACT may not result in an emission limitation which is less stringent than that established under Section 111 or 112 of the Clean Air Act.

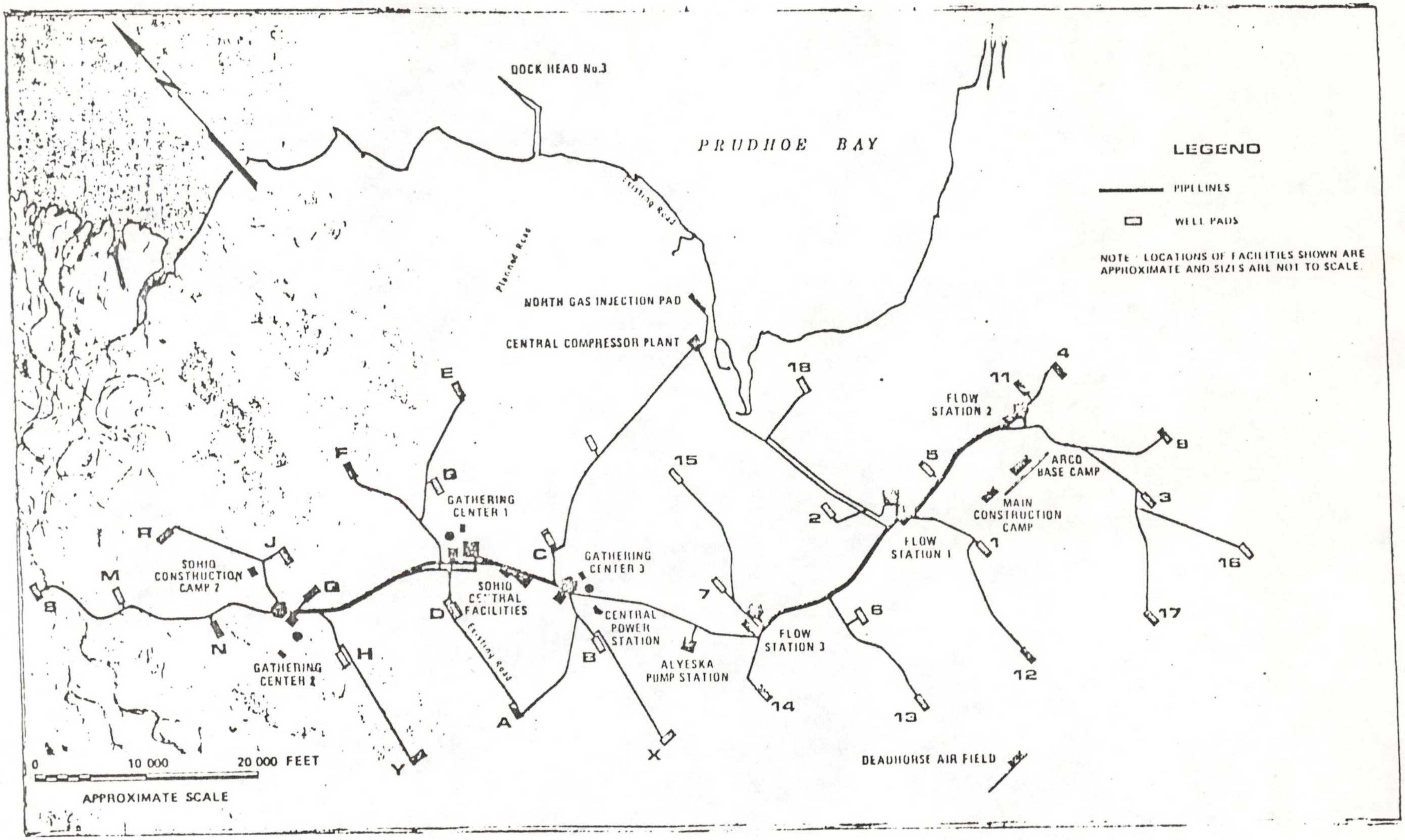

Figure 1 Layout of Project Facilities

TABLE 1

LIST OF ANTICIPATED NEW EMISSIONS SOURCES

Location	Equipment	Rating	Quantity
SOHIO Gathering Center 1	Combustion Turbines	3.5 MHP	2
		1.4 MHP	1
		22.6 MHP	4
	Gas Heaters	42.5 mm Btu/hr	2
		5.0 mm Btu/hr	1
		310.5 mm Btu/hr	1
SOHIO Gathering Center 2	Combustion Turbines	3.5 MHP	2
		1.4 MHP	1
		22.6 MHP	4
		26.6 MHP	3
	Gas Heaters	42.5 mm Btu/hr	3
		310.5 mm Btu/hr	1
		5.0 mm Btu/hr	1
SOHIO Gathering Center 3	Combustion Turbines	3.5 MHP	2
		1.4 MHP	1
		22.6 MHP	4
	Gas Heaters	42.5 mm Btu/hr	2
		5.0 mm Btu/hr	1
		310.5 mm Btu/hr	1
SOHIO Well Pads A, B, C, D, E, F, G, H, J, M, N, Q, R, S, X, Y.	Gas Heaters	10.0 mm Btu/hr	16 (1 per pad)
Central Compressor Plant	Combustion Turbine	25.0 MHP	1
	Gas Heater	26.0 mm Btu/hr*	1
ARCO Flow Station 1	Combustion Turbines	5.0 MHP	2
		36.0 MHP	3
ARCO Flow Station 2	Combustion Turbines	36.0 MHP	4
		5.0 MHP**	2
	Gas Heater	100.0 mm Btu/hr	1
ARCO Flow Station 3	Combustion Turbines	36.0 MHP	4
		5.0 MHP**	2
SOHIO Gathering Centers	Fuel Oil Storage Tanks	42,000 gallons	3 (1 per center)

* Previously permitted by State in June 1979.
**One of these units was previously permitted by the State in June 1979.

TABLE 2

TOTAL POTENTIAL EMISSIONS

FOR NEW SOURCES (TONS/YEAR)

	NO_x	NMHC	CO	PART.	SO_2
Potential	22,645	74.4	4,099	586	18.5

TABLE 3

POTENTIAL AND ALLOWABLE EMISSIONS FROM PROPOSED SOURCES

Source	Potential Emissions, Tons/Year NO_x [1]	CO [2]	Part. [3]	SO_2 [2]
Gas Turbines				
1,400 hp.	36.2	6.8	1.1	0.02
3,500 hp.	90.4	16.9	2.2	0.06
5,000 hp.	129.3	24.1	3.1	0.07
22,600 hp.	584.0	108.9	14.4	0.40
25,000 hp.	646.0	120.5	15.9	0.44
26,600 hp.	687.3	128.2	17.2	0.47
36,000 hp.	930.2	173.5	21.2	0.63

	NO_x [4]	CO [4]	Part. [4]	SO_2 [4]
Gas Heaters				
5 million BTU/hr	4.1	0.4	0.24	0.01
10 million BTU/hr	8.3	0.8	0.48	0.03
26 million BTU/hr	21.9	2.1	1.2	0.07
42.5 million BTU/hr	35.2	3.4	2.0	0.12
100 million BTU/hr	82.7	8.0	4.7	0.28
310.5 million BTU/hr	256.9	25.0	14.7	0.88

1 Based on 150 ppmv NO_2 in flue gas at 15 percent excess O_2, dry basis.
2 Based on AP-42 emission factors for gas turbine compressor engines, table 3.3.2-1.
3 Based on AP-42 emisssion factors for electric utility gas-fired turbines, table 3.3.1-2
4 Based on AP-42 emission factors for natural gas combustion devices, table 1.4-1.

BACT for the Prudhoe Bay Expansion

Since the predicted emission rates for NO_x, CO, and PM as shown in Table 2, exceed the PSD applicability criteria (potential emissions greater than 250 T/yr and allowable emissions greater than 50 T/yr) BACT must be determined for these pollutants.

Gas Turbines

Standards of Performance for Stationary Gas Turbines were promulgated on September 10, 1979 on NO_x and SO_2. Since the ARCO and SOHIO turbines are to be installed after the standards (denoted NSPS) were proposed, they will be subject to the NSPS. These standards limit NO_x emissions from turbines used for oil or gas transportation and production to 150 ppm at 15% oxygen on a dry basis. The NO_x emission limit for gas turbines is modified by a turbine efficiency factor, and the source test results must by adjusted to (ISO) standard day conditions.

The two best systems available for reduction of NO_x from combustion turbines are dry (internal combustion) controls and injection of water or steam. Dry controls are incorporated into the design of the turbine combustion chamber by the manufacturer. Water or steam injection lowers the peak combustion temperature in the turbine and therefore reduces the amount of NO_x formed. NO_x emissions of less than 75 ppm at 15% oxygen can be achieved with water or steam injection.

Dry controls can reasonably be expected to reduce NO_x emissions to the NSPS value of 150 ppm at 15% O_2. A turbine is presently being manufactured with dry controls which will supposedly be able to reduce NO_x emissions to 75 ppm. However, these units are about 70 Mw whereas the largest turbines proposed for use at Prudhoe Bay are 50 Mw. Also, the turbines capable of reducing NO_x emissions to 75 ppm are new and in an unproven stage; therefore, dry controls in combustion turbines of the sort proposed for Prudhoe Bay should be expected to limit NO_x to a maximum of 150 ppm at 15% O_2.

Water or steam injection to limit NO_x emissions is infeasible at the Prudhoe Bay operation primarily because of its geographic location. Alaska's north slope has a shortage of fresh water, a fragile environment, and is extremely cold during much of the year. Water injection requires large quantities of high quality water. The available water in this region is often frozen and contains a relatively high concentration of dissolved solids and related impurities. Alaska also has strict laws regulating commercial water use in order to protect fish and wildlife.

These problems would have to be overcome before water injection could be considered. The cost to the Prudhoe Bay unit owners would be much greater than that typical for the "lower 48" due to the required storage of water for use during low flow periods, installation of water treatment facilities, and increased energy costs to keep the water from freezing during cold periods.

Particulate emissions are best controlled in combustion turbines by natural gas firing. Since the Prudhoe Bay facility intends to use natural gas as the fuel, the BACT emission rate calculated from the projected gas fuel rate is 509 T/yr. An opacity limit of 5% will also be set since visible emissions are quite low for gas turbines operating under good conditions.

Incomplete combustion is the primary cause of carbon monoxide (CO) emissions from stationary gas turbines. CO emissions can best be reduced by maintaining proper combustion conditions by regulating fuel to air ratios, mixing, and combustion temperatures. Since documented evidence is unavailable to indicate that better control is available for CO emissions, the emission limitation based upon natural gas as the fuel and representative of BACT is calculated to be 3986 T/yr for CO.

BACT for Process Heaters

For the process heaters BACT must be determined for NO_x, CO, and particulates. NSPS regulations for process heaters have not been proposed or promulgated as of this time, however, the NSPS for fossil fuel fired steam generators will be used for comparison. These regulations include an NO_x emission limit for gas fired units of 0.20 lb $NO_x/10^6$ BTU and a 25% reduction from potential emissions for fossil fuel fired steam generators with a capacity greater than 250 x 10^6 BTU/hr. Only three of the thirty-one proposed heating units have a capacity greater than 250 x 10^6 BTU/hr, however, this NSPS will be used as a comparison in the analysis that follows.

The company proposed to limit NO_x by burning natural gas. Other NO_x reduction processes such as off stoichiometric combustion, minimizing excess air to the combustion process, and flue gas recirculation were considered by the company but rejected either because of the remoteness or the relatively small size of many of the process heaters.

Low NO_x burners reduce NO_x emissions by improved fuel-air mixing, lower peak flame temperatures, oxygen deficient combustion and flue gas recirculation. These burners have been shown to reduce emissions to the range of 40-75 ppm which represents a 60-75% reduction from the maximum AP-42 emission factor. These burners can reasonably be expected to reduce

NO_x emissions to less than 70 ppm or 35 ng/J (.08 lb $NO_x/10^6$ BTU).

Heaters with a capacity greater than 43 x 10^6 BTU/hr are the major sources of NO_x emissions (contributing approximately 67% of uncontrolled NO_x emissions). In addition, discussion with the applicant indicated that heaters in this size range were to be used as process heaters while the smaller heaters would be used as space heaters. While low NO_x burners have been demonstrated on process heaters, similar demonstration is not available for smaller space heaters at this time. Therefore, each category of heaters will be evaluated separately. The use of low NO_x burners on heaters with a capacity greater than 43 x 10^6 BTU/hr would result in a substantial decrease in emissions over the company's proposed method of natural gas firing alone. (776 T/yr versus 1268 T/yr or a reduction over potential emissions of approximately 39%.) Low NO_x burners should not require dramatically increased upkeep over other types of burners, therefore, BACT for the process heaters with a capacity greater than 43 x 10^6 BTU/hr will be set at .08 lb $NO_x/10^6$ BTU (35 ng/J).

CO and particulate emissions from process heaters are minimized by burning gas rather than oil and by monitoring combustion parameters to maintain good combustion. Either oxygen or carbon monoxide levels in the combustion flue gas can be used as an indicator of good combustion; therefore, the installation of either continuous CO or O_2 monitors will be required for all heaters with a capacity greater than 43 x 10^6 BTU/hr. Installation of these monitors and gas firing will be considered BACT for the process heaters. An opacity limit of 5% will also be set since natural gas-fired combustion devices operating under good conditions should have very low visible emissions. The CO and particulate matter emissions limits for the process heaters are based upon the use of natural gas as the fuel and are calculated to be 123 T/yr and 73 T/yr respectively.

III. Ambient Air Quality Impact Analysis

Based on the total annual emissions listed in Table 2, the proposed new facilities will be subject to air quality review for oxides of nitrogen (NO_x), carbon monoxide (CO), and particulate matter (TSP). Air quality review will not be required for hydrocarbons since the amount of hydrocarbon emissions which are non-methane will be less than 250 tons per year. The air quality analysis must demonstrate that emissions of NO_x, CO, and TSP will not cause or contribute to a violation of an applicable national ambient air quality standards (NAAQS), and that the TSP emissions will not cause a violation of the allowable PSD increments. In addition, the air quality analysis may demonstrate that maximum impacts are below EPA's

Level of Significance, in which case no further analysis is required. Table 4 lists the applicable NAAQS, PSD increments, and Levels of Significance.

A. Existing Conditions

The project area is located in uniformly flat terrain along the northern coast of Alaska, immediately south of Prudhoe Bay on the Beaufort Sea. Figure 1 shows the locations of existing facilities which are spread over an area of about 500 square kilometers. A monitoring network was established in March of 1979, to determine existing air quality and meteorological conditions in the area. Six months of data were available for this analysis.

The locations of the two air quality monitoring stations are indicated in Figure 1 at Well Pad A and Drill Site 9. According to modeling results (discussed in Subsection D below), these monitor locations are not representative of the areas of maximum air quality impact of existing sources. However, since the frequency distribution of wind direction (see Figure 2) is bimodal with an east-west orientation, these locations can be thought of as being essentially up- or downwind of existing sources considering the prevailing wind direction. The maximum values measured at these locations, while not representative of maximum impacts, may be considered as representative of typical downwind impacts resulting from existing sources. In addition, when the wind direction is such that the monitors are upwind of existing sources, the measured values can be considered to be representative of background air quality, i.e., the air quality levels transported into the area from natural or distant anthropogenic sources. The maximum measured and background pollutant levels determined from six months of available data are listed in Table 5. Background levels are very low as expected due to the remoteness of the location. Maximum measured values (excluding periods of wind blown dust) indicate that air quality levels resulting from existing source emissions typically do not approach NAAQS.

Since a full year of meteorological data from the on-site monitoring network is not available, meteorological data from the nearest National Weather Service (NWS) station had to be relied upon to perform model estimates. The nearest NWS station where adequate data is available is located approximately 180 kilometers (km) east of Prudhoe Bay at Barter Island. Since these two locations are separated by such a large distance, there is some uncertainty as to the representativeness of the Barter Island data for the Prudhoe Bay area. The topography and climatology of the two areas are similar, and a comparison of wind direction frequencies for 5 years of Barter Island data and

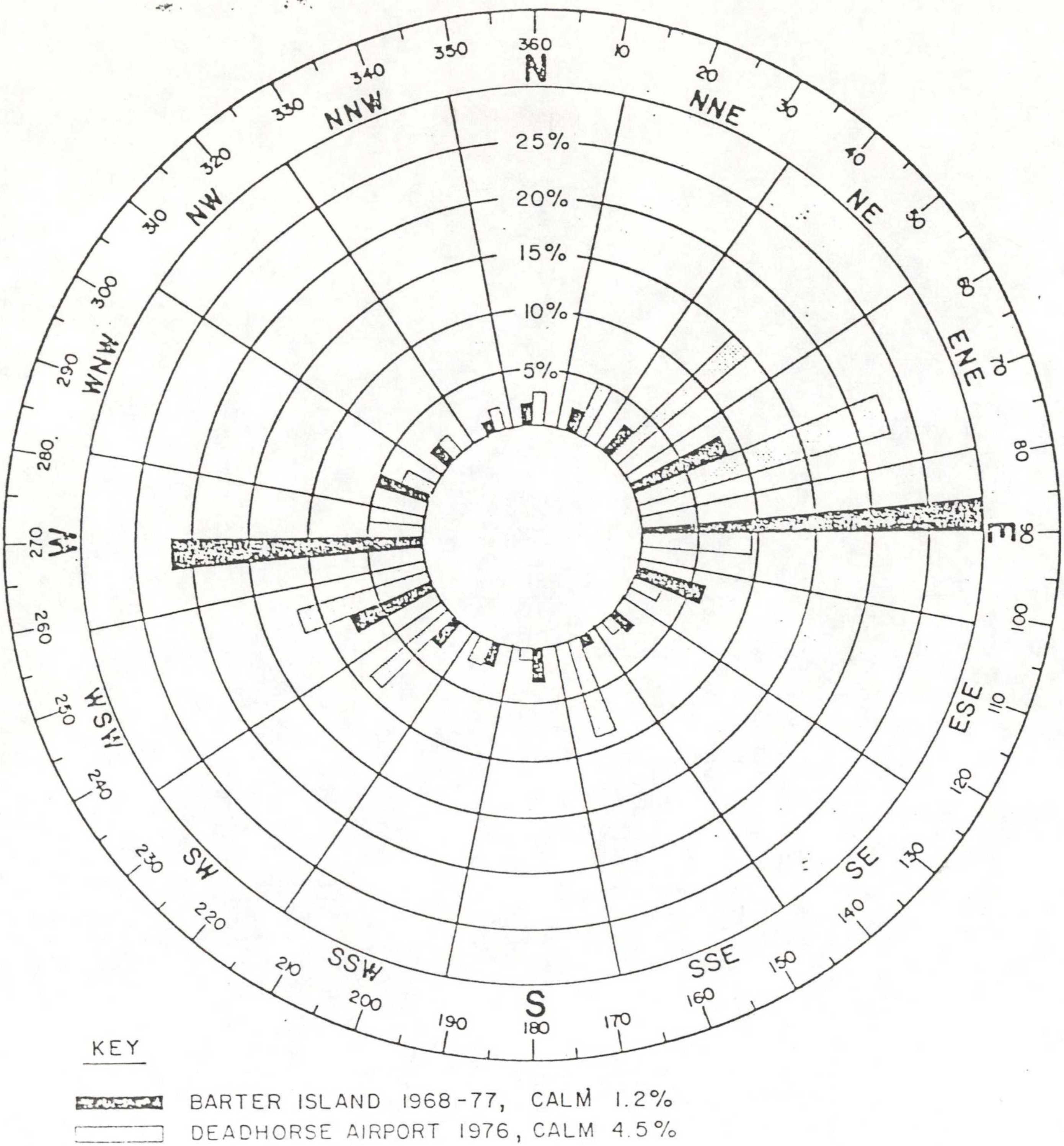

FIGURE 2
ANNUAL WIND FREQUENCY DISTRIBUTION

TABLE 4

Applicable Standards

in micrograms per cubic meter

Pollutant/Averaging Time		NAAQS	PSD Increment	Level of Significance
TSP	24 hour	150	37	5
	Annual	60	19	1
CO	1 hour	40,000	*	2,000
	8 hour	10,000	*	500
NO_2	Annual	100	*	1

* PSD increments have not yet been established.

TABLE 5

Maximum Measured and Background Pollutant Levels

3/16/79 to 10/1/79

in micrograms per cubic meter

Pollutant/Averaging Time		Maximum Drill Site 9	Maximum Well Pad A	Background** Drill Site 9	Background** Well Pad A	NAAQS
TSP	24 hour	112*	294*	15	6	260
	Geometric mean for the approx. 6 mo. period	7.9	15.4	15	6	75
CO	1 hour	3,340	3,120	180	160	40,000
	8 hour	1,023	1,106	180	160	10,000
NO_2	Arithmetic mean for the approx. 6 mo. period	1.9	3.0	1	2	100

* These maximum TSP values were measured on October 3, 1979 and are apparently the result of a dust storm. The second highest measured values were 64 and 88 ug/m^3 for Drill Site 9 and Well Pad A, respectively.

** The higher of the values from the two sites was used for a background level in determining compliance with NAAQS.

6 months of Prudhoe Bay data shows similarities, so that the Barter Island data is judged to be the most representative data available for this analysis.

B. Emission Characteristics

The emissions characteristics of the proposed sources were treated differently in each of the modeling analyses for the three subject pollutants, NO_x, TSP, and CO.

NO_x

The new sources of air emissions proposed by the applicant are listed in Table 6. The final specifications including emission characteristics for this equipment will not be finally determined until after the PSD permit is received. Since a change in the emission characteristics implies a change in air quality impact, an attempt was made in the air quality modeling analysis to use the most conservative of the possible range of emission characteristics. In this way, the worst-case air quality impacts could be calculated and assurance could be provided that NAAQS for NO_2 would not be violated taking into account possible changes in equipment specifications.

Also listed in Table 6 along with the proposed new sources are the NO_x emission rates and other emission parameters which were assumed for the modeling analysis. As an example, at Gathering Center 1, the total emissions from the two proposed 42.5 MMBTU/hr heaters were treated in the model as if they were emitted from one stack with the volumetric flow rate and diameter characteristics of a 15MMBTU/hr heater. Since the smaller heater has a lower volumetric flow rate, the calculated plume rise is lower and thus, for the same emission rate, the estimated air quality impact is greater. It can be seen that this treatment of the emission characteristics should tend to over estimate ambient impacts of NO_2.

Two other conservative assumptions used in the modeling analysis for NO_x were (1) all NO_x was emitted as NO_2 from all sources, and (2) emissions from all sources at each location were from a single point at each location. These assumptions should also cause the ambient NO_2 impacts to be over estimated.

TSP

Each of the proposed new sources listed in Table 6 was modeled with the emission characteristics appropriate for the actual rating, and these values are listed in Table C-3 in Appendix C of the PSD application. The model results using the original proposed equipment specifications indicated the ambient impacts

TABLE 6

Location (See Figure 1)	Type of Sources *	Total HP and/or MMBTU at each Location	Emission Characteristics for Modeling Analysis: Assumed Turbine/ Heater	NO_2 (g/sec.)	Height (meters)	Diameter (meters)	Temp (^oK)	Velocity (m/sec.)
GC-1	3.5M HP turbines	7M HP	3.5 MHP	5.20	16.7	.88	830	50
	1.4M HP turbine	1.4M HP	1.4 MHP	1.04	16.7	.55	830	5[illegible]
	22.6M HP turbines	90.4M HP	22.6 MHP	67.2	16.7	1.71	470	50
	42.5MMBTU/hr heater	85MM BTU	15MM BTU	2.04	7.6	.94	623	10.6
	310.5MMBTU/hr heater	310.5MM BTU	25MM BTU	7.39	7.6	.73	623	10.6
	5MMBTU/hr heater	5MM BTU	5MM BTU	.12	18.3	.43	623	10.6
GC-2**	3.5M HP	7M HP	3.5M HP	5.2	16.7	.88	830	50
	1.4M HP	1.4M HP	1.4M HP	1.04	16.7	.55	830	50
	22.6M HP	90.4M HP						
	26.6M HP	79.8M HP	22.6M HP	126.5	16.7	1.71	470	50
	42.5MMBTU/hr	127.5MM BTU	15MM BTU	3.05	7.6	.94	623	10.6
	310.5MMBTU/hr	310.5MM BTU	25MM BTU	7.39	7.6	.73	623	10.6
	5MMBTU/hr	5MM BTU	5MM BTU	.12	18.3	.43	623	10.6
GC-3***	3.5M HP	7M HP	3.5M HP	5.2	16.7	.88	830	50
	1.4M HP	1.4M HP	1.4M HP	1.04	16.7	.55	830	50
	22.6M HP	90.4M HP	22.6M HP	67.2	16.7	1.71	470	50
	42.5MMBTU/hr	85MM BTU	15MM BTU	2.04	7.6	.94	623	1[illegible]
	310.5MMBTU/hr	310.5MM BTU	25MM BTU	7.39	7.6	.73	623	10.6
	5MMBTU/hr	5MMBTU	5MM BTU	.12	18.3	.43	623	10.6
SOHIO Well Pads A B C D E F G H J M N Q R S X Y	10MMBTU/hr	10MM BTU at each pad	10MM BTU at each pad	.24 at each pad	14	.6	506	14.3

(Continued on next page)

TABLE 6 (Cont'd)

Location (See Figure 1)	Type of Sources *	Total HP and/or MMBTU at each Location	Emission Characteristics for Modeling Analysis: Assumed Turbine/ Heater	NO_2 (g/sec.)	Height (meters)	Diameter (meters)	Temp (^{o}K)	Velocity (m/sec.)
Central Compressor	25M HP	25M HP	22.6MHP	18.58	16.7	1.71	470	[illegible]
	26MMBTU/hr	26MM BTU	26MMBTU	.63	9.1	.9	519	14.1
Flow Station 1	5M HP	10M HP	5M HP	7.45	16.8	1	748	29.7
	36M HP	108M HP	22.6	80.29	16.7	1.71	470	50
Flow Station 2	5M HP	10M HP	5M HP	7.45	16.8	1	748	29.7
	36M HP	144M HP	22.6	107.0	16.7	1.71	470	50
	100MMBTU/hr	100MMBTU/hr	100MMBTU	2.39	18.3	1.94	623	10.6
Flow Station 3	5M HP	10M HP	5M HP	7.45	16.8	1	748	29.7
	36M HP	144M HP	22.6	107.05	16.7	1.71	470	50

* MHP = Thousand horsepower; MMBTU/hr = Million British Thermal Units per hour.

** Also modeled as a 22.6M HP turbine with heat recovery, was the 65M HP previously permitted (PSD submitted August 2, 19[illegible] approved May 17, 1979).

*** Also modeled as a 22.6M HP turbine with heat recovery was the 34M HP previously permitted (PSD submitted August 2, 1978, approved May 17, 1979).

would be low enough that further modeling would not be necessary (see Subsection D). As with NO_x, TSP emissions from all sources at each location were assumed to be emitted from a single point at each location.

CO

To determine if CO impacts from proposed sources would be below the Levels of Significance, some unrealistic but very conservative assumptions were made concerning CO emission characteristics. The CO emissions from all proposed and existing sources at Prudhoe Bay were summed and were assumed to be emitted form one large process heater stack. Even though most of the CO emissions are from the gas turbines, the process heater stack parameters were employed to be conservative since plume rise is less for the heaters than for the turbines.

None of the proposed stack heights exceed good engineering practice (GEP) as determined by proposed EPA regulations (Federal Register, Vol. 44, No. 9, January 12, 1979). In fact, some stack heights are low enough that building-wake induced downwash may occur. Methods used to estimate potential impacts resulting from downwash are discussed in the next Subsection.

C. Model Methodology

Annual TSP and NO_2

To estimate the maximum annual TSP and NO_2 levels, the Texas Climatological Model (TCM) was employed. TCM is designed for simulating long-term dispersion of non-reactive pollutants emitted from multiple sources in an urban area, and is similar in concept to EPA's Climatological Dispersion Model (EPA-R4-73-024). TCM is listed as a recommended model for multi-source urban complexes in EPA's "Guideline on Air Quality Models" (EPA-450/2-78-027). The Prudhoe Bay area is not an urban area, so there is some question as to the appropriateness of TCM for this application. Impacts in flat terrain from sources with large effective plume heights, such as gas turbines, are generally greater during more unstable atmospheric conditions. This is because during stable conditions, the elevated plumes travel relatively large distances and undergo considerable dispersion before reaching ground-level. During unstable conditions, the plumes are more rapidly mixed to the ground resulting higher ground-level concentrations. An urban model such as TCM differs from a rural model in that stable conditions are assumed to occur less frequently in the urban model. The result is that if an urban model is applied to sources with large effective plume heights which are located in a rural area, the concentration estimates should be conservatively high. For this application then the use of TCM may not be appropriate but is considered conservative.

A modification was made to TCM to reduce the calculated plume rise for gas turbines by a factor of 0.7 during neutral and unstable conditions. At the time when EPA recommended this adjustment, it was believed that, based on some field investigations, increased entrainment or building-wake downwash affecting the hot effluent as it was emitted from the short turbine stack resulted in reduced plume rise. It is now recognized that the technical basis for recommending this adjustment is very limited, and the inclusion of this modification is considered conservative. Comparitive model runs with and without the 0.7 factor have shown that its use increases estimated impacts from gas turbines by an insignificant amount.

Input to TCM included the emissions characteristics listed in Table 6 for the proposed new NO_x sources and in Appendix C of the application for existing and previously permitted NO_x sources and all TSP sources. The meteorological input for the annual calculation was the stability wind rose for the period 1958-1964 for Barter Island. Two levels of receptor grid resolution were employed. First, a course receptor spacing of 2 km was used to identify critical impact areas. Then, a 0.25 km spacing was used in these areas to identify maximum concentrations. Since heights for other proposed stacks, in addition to the turbine stacks, are below GEP, the potential for large impacts due to downwash was investigated. Techniques for determining downwash impacts on an annual basis are somewhat tenuous; but it was believed that with a large amount of conservatism built into the methods, it could at least be determined whether or not major downwash problems might be expected. The details of the methodology are adequately explained in the PSD application (Section 8.6 and Appendix D) and will not be repeated here. The results of the investigation indicate that, while there is the potential for elevated concentrations near buildings due to downwash effects, it does not appear that the annual NAAQS will be threatened.

Short-term TSP

To determine whether the short-term TSP impact of the proposed sources would be significant, a two model approach was employed. First, the EPA CRSTER model (EPA-450/2-77-013) was used repetatively to model all of the new sources at each of the major locations to identify the meteorological conditions associated with the worst-case 24-hour TSP impacts. Then the EPA RAM model (EPA-600/8-78-016) was used to estimate the combined impact of all new sources for the worst-case day.

CRSTER is appropriate for rural, flat-terrain situations. It calculates hour-by-hour concentrations for a year or more of hourly meteorological input data. Thus, the meteorological conditions which cause the highest 24-hour impact can readily be identified. The emission characteristics of the proposed sources at each location listed in Appendix C of the application were input to CRSTER. One year (1964) of meteorological data (i.e., hourly values of wind speed, wind direction, stability, mixing height and temperature) were also input to the model. EPA guidance (EPA-450/2-78-027) recommends five years of this type of data if it is available. This data could be developed from additional years of Barter Island observations, however the resultant TSP impacts for the one year of data are so low (see Subsection D) that additional modeling is not required.

Since CRSTER does not consider the spatial separation of sources, the RAM model had to be relied upon to determine combined impacts. RAM is a multi-source, flat-terrain model with both rural and urban versions. The rural version (RAMR) which was used here is now not recommended for use by EPA since some of the assumptions in RAMR are not consistent with the CRSTER model. EPA has developed a model (MPTER) to replace RAMR, however it is not generally available at this time. The inconsistencies in RAMR are probably not significant for this application since the calculated TSP impacts are so low.

The characteristics of all proposed new sources listed in Appendix C of the application were used in RAMR along with the worst-case 24-hour meteorological conditions identified by CRSTER. A receptor grid spacing of one km was used initially to locate maximum impact areas; then a refined receptor grid of 0.25 km spacing was used in these areas to define maximum impact values.

As with TCM, both CRSTER and RAM were modified to apply a 0.7 factor to the calculated plume rise of gas turbines during neutral and unstable conditions.

CO

Since the CO emissions from the proposed new sources are low and expected impacts would be low compared to the relatively high NAAQS for CO, a very simple screening analysis was used to predict ambient levels. The CO emissions from all proposed and existing stationary sources at Prudhoe Bay were summed. All the CO emissions were then modeled with the EPA PTMAX model as if eminating from a single source a 310 MMBTU/hr process heater. The plume rise from heaters is not as great as that from turbines, so that predicted ground-level concentrations are greater for the same emission rate. PTMAX estimates the maximum one-hour impact of a source for a wide range of wind speed and stability conditions. The highest of the estimated concentrations can then be compared to Levels of Significance. An eight-hour concentration can be obtained by multiplying the one-hour value by 0.7. Although this methodology for determining maximum CO impacts is unrealistic, it is very conservative, i.e., it over estimates concentrations.

D. Model Results

CO--Using the very conservative modeling methodology, the maximum one-hour CO concentration was 723 ug/m^3 and the 8-hour value was 506 ug/m^3. The worst-case meteorological conditions for which the model indicated the highest concentrations were neutral (Class D) stability with a strong wind speed of 15 meters per second. The maximum one-hour estimate is below EPA's Level of Significance of 2000 ug/m^3. The 8-hour value is about equal to the Level of Significance of 500 ug/m^3. However, due to the conservative nature of the model methodology, the CO impacts are expected to be insignificant and no further analysis for CO is required.

TSP--Considering the emissions from proposed new sources only, the maximum impact estimate on an annual basis was about 0.2 ug/m^3, which is below the Level of Significance of one ug/m^3. The maximum 24-hour ground-level concentration was about 2 ug/m^3 which is less than the Level of Significance of 5 ug/m^3. The worst-case meteorological conditions which led to the highest 24-hour estimate were strong, persistent easterly winds and neutral stability for the entire day. Due to the low levels of expected impact, no further analysis for TSP is required.

NO_2--From an analysis of the modeling results for NO_2, it was found that the maximum impact area for all existing and proposed sources did not coincide with the area of maximum impact produced by the proposed new sources alone. The maximum impact due to proposed sources alone was about 21 ug/m^3 and occurred about 1.7 km west of Gathering Center 1 (Figure 1). The total ambient concentration at this point including all sources and background was 29 ug/m^3. The maximum impact due to both proposed and existing sources, including a background value of 2 ug/m^3, was 72 ug/m^3. This is less than the annual NAAQS for NO_2 of 100 ug/m^3. The location of this maximum point was about 2 km north of the "town" of Deadhorse. The sources which contributed the major portion of the maximum impact were relatively small diesel generators located in the area. The proposed new sources contributed only a little over 3 ug/m^3 to this maximum value according to the model.

E. Other Impacts

The predicted concentrations of NO_2 due to proposed new sources is relatively low, so that effects of NO_x emissions on soils and vegetation in the Prudhoe Bay area are expected to be insignificant. Significant impairment of visibility by direct emission of particulate matter is not expected. The potential exists for some visibility impairment at larger distances from the sources due to the transformation of NO_x emissions to nitrate particles. Here again, however, effects are expected to be very minimal. A problem of visibility impairment apparently already exists in the Prudhoe Bay area. Fog and ice fog are created or enhanced to some degree by existing sources. The addition of the proposed new source may exacerbate this situation. The Class I area nearest to Prudhoe Bay is about 750 km to the south, and no significant impacts from the proposed new sources are expected at this large distance.

IV. Findings and Recommendations

Based on the results of the ambient air quality analysis, emissions of NO_x from the proposed new sources are not expected to cause or contribute to a violation of the NAAQS for NO_2. Impacts from CO and TSP emissions are expected to be insignificant.

Emissions Limitations

Maximum emissions levels based on the BACT evaluation are tabulated in Tables 7 and 8. Table 7 lists maximum total emissions by the type of equipment involved and the proposed location of the equipment on the site. Table 8 lists total emissions by the type of equipment involved along with emissions factors for the various pollutants.

Compliance Determination

Compliance with the emissions limitations shall be demonstrated by the company conducting source tests and a program of emissions monitoring as described below.

(1) Compliance testing shall be conducted for each of the groups as identified in Table 7 within 60 days after achieving the maximum production rate at which the turbines (and process heaters) will be operated but not later than 180 days after the initial startup of each of the individual expansion projects. NO_x shall be tested as required under the NSPS (40 CFR 60.335) for the gas turbines, and EPA Method 7 shall be used for the process heaters. No compliance testing is required for HC, CO, or particulate matter.

(2) Compliance Monitoring--In addition to the NSPS monitoring requirements, a continuous monitoring system shall be installed to monitor either O_2 or CO for all gas fired heaters with a capacity greater than 43 x 10^6 BTU/hr.

Monitoring records should be available to EPA upon request and should be maintained for a period of two years.

TABLE 7

Emissions Limitations

Location	Equipment	Pollutant (tons/yr) NO$_x$	CO	Part.
G.C. #1	Turbines	2553	476	63
	Heaters	184	32	19
G.C. #2	Turbines	4615	861	115
	Heaters	219	36	21
G.C. #3	Turbines	2553	476	63
	Heaters	184	32	19
Well Pads	Heaters	133	13	8
Central Comp. Plnt	Turbines	646	120	16
	Heaters	22	2	1
F.S. #1	Turbines	3049	569	70
F.S. #2	Turbines	3979	742	91
	Heaters	35	8	5
F.S. #3	Turbines	3979	742	91
Total		22151	4109	582

TABLE 8

Total Emissions Limitations

Source	Pollutant	(Tons/Yr)	Emissions Factor
Gas Turbines	NO_x	21,375	150(14.4/Y)ppm**
	CO	3,986	109.6 lb $CO/10^6$scf (fuel)
	PM	509	14 lb $PM/10^6$ scf (fuel)
			5% Opacity Limit
Process Heaters			
$>$(43×10^6 BTU/hr)	NO_x	361	.08 lb $NO_x/10^6$ BTU
$<$(43×10^6 BTU/hr)	NO_x	415	.19 lb $NO_x/10^6$ BTU
	CO	123	.018 lb $CO/10^6$ BTU
	PM	73	.011 lb $PM/10^6$ BTU
			5% Opacity Limit

** NO_x emissions factor for gas-fired turbines is modified by an efficiency factor (Y) which can not exceed 1.4 kilojoules/watt.hour (manufacturer's rated heat rate at rated peak load).

Based at 15% oxygen on a dry basis.